



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICANT : Dan Lillie et al.
SERIAL NO. : 10/073,503
FILED : February 11, 2002
FOR : ETCHING SOLUTION FOR FORMING
AN EMBEDDED RESISTOR
CONFIRMATION NO. : 5980
EXAMINER : Robert P. Culbert
ART UNIT : 1763
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AFFIDAVIT UNDER 37 C.F.R. 1.132

1. The undersigned, Jiangtao Wang, is a co-inventor of the above-identified U.S. Patent Application Serial No. 10/073,503 (hereinafter referred to as the “‘503 application”).

2. The undersigned is Manager R & D of Nikko Materials USA, Inc., assignee of the ‘503 application.

3. The undersigned has 7 years of experience in the copper foil industry.

4. The undersigned is familiar with U.S. Patent No. 4,370,197 to Abolafia et al. and U.S. Patent No. 4,160,691 to Abolafia et al., both references having been cited in the above-identified ‘503 application (hereinafter referred to as “the cited references”).

5. The ‘503 application relates to an etching solution for etching resistive materials containing nickel (Ni) and chromium (Cr).

6. The cited references are directed to etching solutions for etching chromium.

7. Nickel chromium (NiCr) alloys are very different from chromium (Cr). Nickel, chromium, aluminum and silicon (Ni/Cr/Al/Si) is very different from nickel-chromium (Ni/Cr).

8. Ni/Cr/Al/Si is more difficult to etch than Ni/Cr or Cr.

9. While some chromium etching solutions may be used to etch a Ni/Cr alloy, it has been observed that the etching rates of such chromium etching solutions will decrease significantly as the following ratio increases:

$$\frac{C_{SA}}{R_{SA}} = \frac{\text{the surface area of copper exposed to the etching solution}}{\text{the surface area of Ni / Cr alloy exposed to the etching solution}}$$

10. The C_{SA}/R_{SA} ratio may increase to a value where the chromium etching solution is ineffective to etch a Ni/Cr alloy.

11. While some chromium etching solutions may be used to etch a Ni/Cr alloy layer, these etching solutions may be unsuitable for certain applications because the chromium etching solutions will dissolve treatments (e.g., adhesion-promoting treatments, thermal barrier treatments, strain proofing treatments, and resin resistant coating treatments) that are deposited on the copper surface to enhance the peel strength and shelf life of a resistive foil.

12. The present invention was developed to address the drawbacks described above in items 9, 10 and 11.

13. Neither of the cited references teach an etching solution that would work for etching a Ni/Cr alloy having at least one of aluminum and silicon. Abolafia et al. '197 shows, by way of example, an etching solution comprised of sulphuric acid, thiourea and water. Even if the etching solution were comprised of hydrochloric acid (HCL), and thiourea, as suggested in Abolafia et al. '197, the etching solution would not be suitable for etching Ni/Cr alloys (having at least one of aluminum and silicon) on copper. If hydrochloric acid (HCL) is used in place of sulphuric acid, with thiourea at levels taught in the '197 patent, the resulting etching solution would etch copper in addition to the Ni/Cr alloy.

14. More specifically, in searching for an etching solution to etch Ni/Cr/Al/Si, I prepared and tested etching solutions as taught by both of the cited references. Neither solution was suitable for etching Ni/Cr/Al/Si. As indicated above, I attempted to combine the teachings of the cited references by using an etching solution comprised of hydrochloric acid, thiourea and glycerin in the amounts taught by the cited references. The amount of each component was as follows 43 volume % HCl, 46 volume % glycerin, 1 weight % thiourea, and water balance to 100% volume. The resulting solution was not acceptable for etching Ni/Cr/Al/Si, since it also etched copper.

15. It was found that very small amounts of thiourea in combination with hydrochloric acid and glycerin, produced a solution that would etch Ni/Cr/Al/Si without etching copper, provided an acceptable etching rate, did not dissolve treatments, and etched fine lines (10 mil spacing).

Date: 9-3-04

Signature: 

Name: Dr. Jiangtao Wang

Title: Manager R & D

Company: Nikko Materials USA, Inc.